a strychnine or cinchonine salt of the thetine hydrobromide, or a malate of the base. Pope and Peachey succeeded in preparing two salts of the thetine with active acids (dextrocamphorsulphonic and dextro-α-bromocamphorsulphonic acids), but found that no resolution of the asymmetric thetine into optically active components occurs. Hence they draw the conclusion that if sulphur really exists as a quadrivalent element in these salts, the four atoms directly and independently attached to the sulphur lie in the same plane as the latter.

THE additions to the Zoological Society's Gardens during the past week include an Entellus Monkey (*Semnopithecus entellus*) from India, presented by Mrs. E. J. Gaudie; a Red Deer (*Cervus elaphus.* ♂) from Scotland, presented by the Right Hon. the Marquis of Breadalbane, K.G., P.C.; a Spanish Blue Magpie (*Cyanopolius cooki*) from Spain, presented by Mr. L. Ingram Baker; an Alligator Terrapin (*Chelydra serpentina*), a Floridan Terrapin (*Chrysemys concinna*), a Salt-water Terrapin (*Malacoclemmys terrapin*), a Sculptured Terrapin (*Clemmys insculpta*), four American Box Tortoises (*Cistudo carolina*), a Prickly Trionyx (*Trionyx spinifer*), two Reeves's Terrapins (*Damonia reevesi*), a Blue Lizard (*Gerrhonotus coeruleus*), a Three-striped Boa (*Lichanura trivirgata*), two Striped Snakes (*Tropidonotus sirtalis*), a Seven-banded Snake (*Tropidonotus septemvittatus*), four Corn Snakes (*Coluber guttatus*), a Chicken Snake (*Coluber obsoletus*), an American Black Snake (*Zamenis constrictor*), two King Snakes (*Coronella getula*), nine Changeable Tree-Frogs (*Hyla versicolor*) from North America, a Common Boa (*Boa constrictor*), an Annulated Terrapin (*Nicoria annulata*) from South America, eight Adorned Terrapins (*Chrysemys ornata*) from Central America, a Wrinkled Terrapin (*Chrysemys scripta rugosa*) from the West Indies, two Grooved Tortoises (*Testudo calcarata*) from South Africa, a Starred Tortoise (*Testudo elegans*) from India, deposited; two Tceheli Monkeys (*Macacus tcheliensis*, ♂ ♀) from Northern China, presented by Dr. S. W. Bushell; a Vulpine Phalanger (*Trichosaurus vulpecula*) from Australia, presented by Miss Freda Gilder; three Dial Birds (*Copsychus saularis*) from India, purchased.

OUR ASTRONOMICAL COLUMN.

DEFINITIVE ORBIT OF COMET 1897 III.—Herr E. Wessell, of the Helsingfors Observatory, has reduced 168 observations of Perrine's Comet, 1897 III, made at various observatories, and gives the resulting definitive elements of the orbit in the *Astronomische Nachrichten*, Bd. 151, No. 3614, as follow:—

Definitive Elements of Comet Perrine (1897 III.).

T = 1897 Dec. 8·679793 Berlin Mean Time.

$$\left.\begin{array}{rl} \omega = & 65^{\circ}\ 53'\ 57''\cdot 6 \\ \Omega = & 32\ \ \ 3\ \ \ 8\cdot 7 \\ i = & 69\ \ 35\ \ 58\cdot 2 \end{array}\right\} 1897\cdot 0.$$

$$\log q = 0\cdot 132477$$

NEW VARIABLE STAR IN DRACO.—Dr. T. D. Anderson, of Edinburgh, has communicated to the *Astronomische Nachrichten*, No. 3618, his recent discovery of the variability of a star having the following position:—

$$\left.\begin{array}{ll} \text{R.A.} & 17\text{h. } 55\cdot 6\text{m.} \\ \text{Decl.} & +54^{\circ}\ 51' \end{array}\right\} 1855.$$

The variation in magnitude is from 9·4 to 10·4. Neither the variable nor the four stars used for comparison are mentioned in the *Bonn Durchmusterung*.

TIME USED IN EPHEMERIDES.—With the current number of the *Observatory* is issued a slip stating that the variable star ephemerides, published in the *Annual Companion*, are given in Greenwich civil time, and not in astronomical time, as heretofore. The day is divided into 24 hours, and begins at midnight. This change was rendered necessary by reason of its having been adopted by M. Loewy in the *Annuaire du Bureau des Longitudes*, from which the data for the variable star ephemerides are obtained. It is thought that this change is responsible for the recent misleading reports as to the adoption by the principal observatories of the civil time reckoning.

LEONID METEORS.—Signor E. Fergola contributes to the *Rendiconto* of the Naples Academy a note on observations of the Leonid shower, made at the Observatory at Capodimonte. The numbers of meteors observed on November 14, 15, 16 and 17 were 15, 30, 32 and 11, and the radiant point, as determined by conjoint observations of Signori Alberti, Tedeschi and Nobili, was in R.A. 10h. 8m., and declination 23°4s.

THE FUNCTIONS OF THE ENGINEER.[1]

THE success of the modern engineer is due to the fact that he has buried in the depths of oblivion the much-vaunted empirical rule of thumb, and that he has elevated to the heights of science the observations of exact practice and the exercise of pure reason. The principle of doubt, which is the root of all scientific inquiry, forces him to consider every phase of weakness in the materials that he employs in his structures, to examine every possible cause of error in his designs, to anticipate every source of failure in his work. The principle of faith, which is the outcome of the growth of his experience, must be continually illuminated by the light of progress, and controlled by the patient development and consideration of the too-long-hidden laws of nature. The engineer must maintain his acquaintance with ever-growing science so as to be able to fulfil promptly and accurately his duty, which is the application of the great principle of energy and the utilisation of the marvellous properties of matter to the wants, comfort and happiness of man.

In considering the functions of the engineer we have to consider his *practice* and his *making*.

His practice—what has he got to do? The practice of engineering can be divided into three branches: Civil, Military and Naval.

The term civil was originally introduced to distinguish the practical man of peace from the practical man of war. Engineering applied to our wants and comforts is a very different thing to that applied to the destruction of our foes or to protect ourselves from their wish to destroy us. War is waged both on land and sea, and as the conditions involved in attack and defence in modern times have become so totally different in these two cases, the term military has been gradually confined to the operations of our army on land, while the term naval is applicable to the warlike operations of our fleets. England owes her present position as the centre of a great empire to her naval supremacy, and she has acquired this supremacy as much by the inventive, constructive and maintaining powers of her working engineers as by the mighty deeds of her fearless fighting sailors.

Civil engineering aids us not only to build that haven of rest and comfort that we call home, but to surround it with the elements of health—pure air, pure water, pure food, pure light. If we congregate together in towns or scatter ourselves in country districts it supplies us with all possible means of transport by road, river and rail, and of means of intercommunication by post, telegraph and telephone. These means of annihilating time and space are not only inter-urban in our own country but international in our continents, and in a wider sense imperial, cosmical and universal, over the whole earth. The world is knit in one connected whole by wire. We know to-day from that triumph of art, science and culture—the intelligent and free British daily public Press—the history of nearly all that took place yesterday over the whole globe.

The engineer fears not the infinitely great, for the stars in their courses aid him to survey the land and to cross the deep with safety. He spurns not the infinitely little, for the molecules in their mutual actions and reactions supply him with those metals and those elements of purity and strength which give him the means to resist the forces of nature so as to span the broad channel, laugh at the foaming river, build the palace of glass at Sydenham, cover acres of ground so as to display this year in Paris the goods, manufactures, and works of art, industry and utility of the whole world.

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[1] An address by Sir William Henry Preece, K.C.B., F.R.S., delivered before the Glasgow Association of Civil Engineers on February 8.

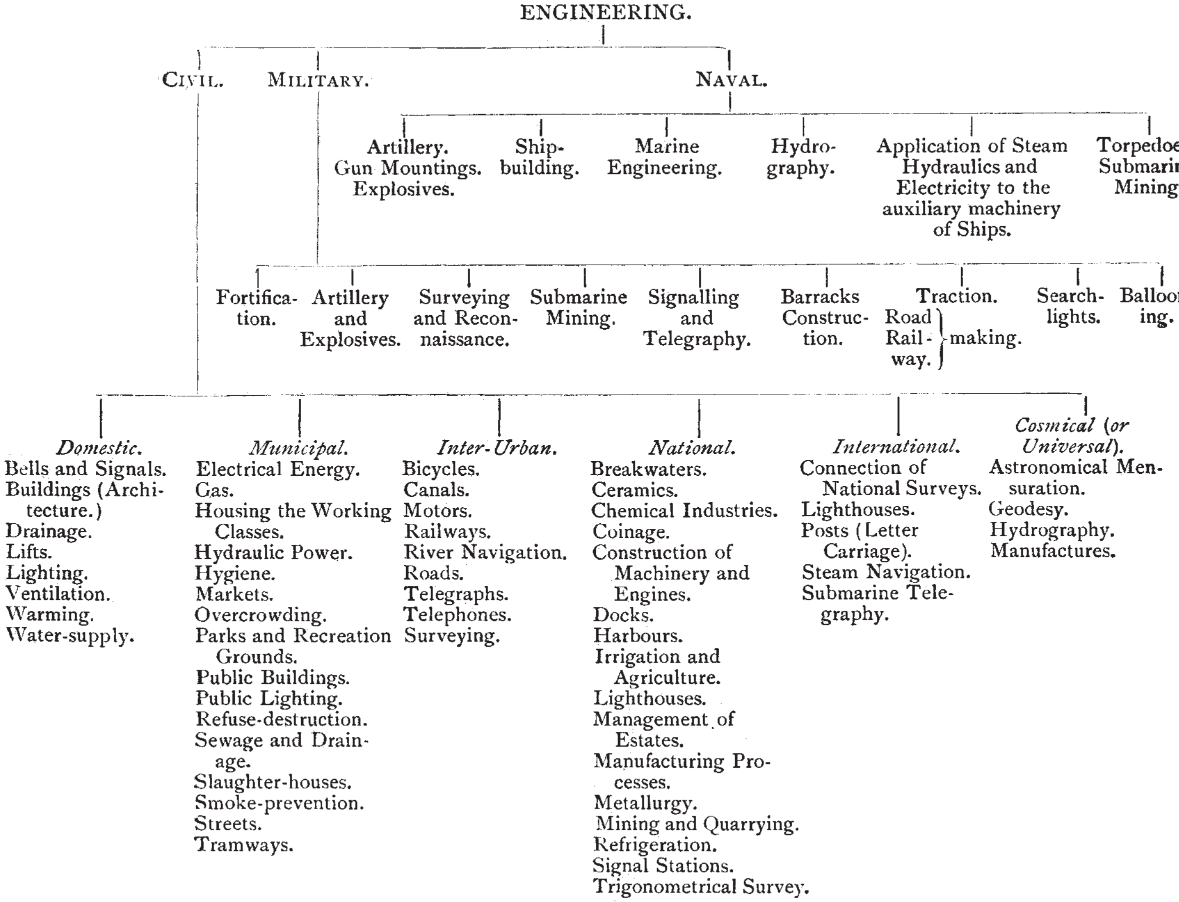
The engineer utilises matter wherever it can be found; he delves into the crust of the earth for ores and minerals which give him wealth, currency, protection and strength; he dives into the sea to survey the bottom as a bed for his cables, and to see that he has secured proper foundations for his moles, piers and breakwaters; he explores the surface of the earth for articles of necessity, of use and of luxury. He irrigates the land, to prepare it for the growth of pure and wholesome food, for the supply of cheering and sustaining drinks, for the maintenance of the stores on the shelves of the doctor, and for those articles of pure clothing that add so much to the comfort, cleanliness and health of man. He utilises for his purpose the great principle of energy, so as to transform it at his will into its various forms of heat, light, electricity, sound, chemism and material motion. By these agencies he transforms crude matter into its various elements, compounds and states, so as to secure permanence, strength and value.

Life is not free from his grasp. He has developed the Empire of Bacteria, and has encouraged the minute microbe in countless armies—to liquefy and purify our sewage, and to become the scavenger of our homes and our cities. He has by defensive measures freed the soil and the river from those ruthless bacterial enemies who invade our frames and bring disease and death in their train.

Engineering is divided into various sections, many of them having their own institutions and their own publications.

The definition of a civil engineer, as given in the charter of the institution, is very comprehensive. This institution is "a society for the general advancement of mechanical science, and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of a civil engineer, being the art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange, and in the construction of ports, harbours, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and adaptation of machinery, and in the drainage of cities and towns."

It is difficult to classify the sections of engineers into any logical order; but I have attempted in the following table to arrange methodically the various branches upon the same principle as we draw up a genealogical tree, for every branch emanates by direct descent from the one root, engineering, which is applied science.



ENGINEERING.

- CIVIL.
  - *Domestic.*
    - Bells and Signals.
    - Buildings (Architecture.)
    - Drainage.
    - Lifts.
    - Lighting.
    - Ventilation.
    - Warming.
    - Water-supply.
  - *Municipal.*
    - Electrical Energy.
    - Gas.
    - Housing the Working Classes.
    - Hydraulic Power.
    - Hygiene.
    - Markets.
    - Overcrowding.
    - Parks and Recreation Grounds.
    - Public Buildings.
    - Public Lighting.
    - Refuse-destruction.
    - Sewage and Drainage.
    - Slaughter-houses.
    - Smoke-prevention.
    - Streets.
    - Tramways.
  - *Inter-Urban.*
    - Bicycles.
    - Canals.
    - Motors.
    - Railways.
    - River Navigation.
    - Roads.
    - Telegraphs.
    - Telephones.
    - Surveying.
  - *National.*
    - Breakwaters.
    - Ceramics.
    - Chemical Industries.
    - Coinage.
    - Construction of Machinery and Engines.
    - Docks.
    - Harbours.
    - Irrigation and Agriculture.
    - Lighthouses.
    - Management of Estates.
    - Manufacturing Processes.
    - Metallurgy.
    - Mining and Quarrying.
    - Refrigeration.
    - Signal Stations.
    - Trigonometrical Survey.
  - *International.*
    - Connection of National Surveys.
    - Lighthouses.
    - Posts (Letter Carriage).
    - Steam Navigation.
    - Submarine Telegraphy.
  - *Cosmical (or Universal).*
    - Astronomical Mensuration.
    - Geodesy.
    - Hydrography.
    - Manufactures.
- MILITARY.
  - Fortification.
  - Artillery and Explosives.
  - Surveying and Reconnaissance.
  - Submarine Mining.
  - Signalling and Telegraphy.
  - Barracks Construction.
  - Traction. Road, Railway-making.
  - Search-lights.
  - Ballooning.
- NAVAL.
  - Artillery. Gun Mountings. Explosives.
  - Ship-building.
  - Marine Engineering.
  - Hydrography.
  - Application of Steam Hydraulics and Electricity to the auxiliary machinery of Ships.
  - Torpedoes. Submarine Mining.

The growth of invention in early ages was very slow. Man sheltered himself in caves. How long did it take him to devise a tent, or a hut, or a house? How long to protect himself with clothing? How long to construct weapons of offence and defence, not only to protect himself from wild beasts and from his neighbours, but to secure for himself food and raiment? The first protection from weather was probably the skins of the animals he hunted, killed and ate, and the first art acquired—the making of leather. How long did it take him to obtain a knowledge of the use of fire, and of the means of producing it artificially, so as to cook his food and to bake the plastic clay into pots and pans for drinking and eating purposes?

We have no record of these early stages of the evolution of the human being. The first known picture depicts him as a hunter. Ages elapsed before the conception of a record "engraved upon the rock forever" seems to have occurred to him, and though stone, papyrus, clay, skin and wax gave him material upon which he could record in elementary pictures his victories, his virtues, and his commands, many centuries passed before the greatest invention the world has ever acquired—the alphabet—occurred to some smart Phœnician, probably in the land of Egypt, where picture-writing, hieroglyphy, had reached its acme. It has taken 3000 years to mature this invention. The alphabet we use to-day is a direct descendant of that first Phœnician attempt to indicate the elementary sounds of speech by letters. But what a change has occurred since the next great invention in this direction—printing! The brain is now excited by the publication of every new fact extracted from Nature's storehouse. Inventions spring up like mushrooms. They are published by the Press to the whole world at once. Innumerable minds of all nations are thus set to work to utilise, develop and improve them. Advance is rapid, and progress proceeds at a compound interest rate. I said it took 3000 years to mature the alphabet. It has taken 450 years to perfect printing, but sixty years in our days have matured telegraphy and photography, and only sixty months have been sufficient to apply Röntgen rays to assist the physician to apply his gentle art to restore to health the maimed and wounded. Such is the advantage of publicity!

Why such marvellous constructive skill and scientific progress should have been developed on the banks of the Euphrates and the Nile on the old, and in Mexico and Peru on the new continent, so early in the history of the world, is a mystery of the development of the mind that remains to be satisfactorily explained as much as the persistent conservatism of the negro and the gipsy of the present day. The wicker hut depicted on Egyptian bas reliefs 3000 years ago is the same dwelling-place of the same race in the present day!

The luxurious, roomy, and well-warmed southern villa of their Roman conquerors failed to commend itself permanently to the mind of the unrefined ancient Briton. Nevertheless, the Roman taught us the arch, showed us how to build a bridge, and left us his straight and admirable road. The words arch, pont and street remain in our languages historical memorials of those early colonists.

The rapid progress of modern engineering is phenomenal. Practice grows by leaps and bounds. Take any form of energy and examine its utilisation in any field of industry. Take only one instance of the application of electricity. See how it comes to the aid of the sailor! It controls the rudder, it ventilates the interior and the living space of the ship, it forces the draught and assists the raising of steam, it revolves the turrets, it trains and controls the guns, it handles the ammunition, it purifies the drinking water, it lights up the ship internally, it enables the captain to sweep the horizon with the brilliant rays of the search-light, and to communicate with his tender, or with his commanding officer across space independent of weather, night, season, fog or rain. It would lengthen this address too much to illustrate this point further. Light, sound, heat, chemism and mechanics have been equally active in the service of man, and have helped to specialise in many directions the functions of the engineer.

The Making of the Engineer.—It is idle to ignore the fact that the modern engineer is the outcome of high-class and long-sustained education, either imparted or self-acquired. Education means generally the training of the intellectual, moral and physical faculties of youth, but the education of the engineer never ceases as long as he remains in active practice. I am still in school, and rarely fail to acquire some new fact each day of my life. The first foundation is clearly a broad, solid, general education, not specialised in any way until the pupil has reached the stage when he can work and think for himself. But from the very earliest years—in fact, from infancy—I advocate the cultivation of the powers of observation, a systematic training of the memory, and an encouragement of the exercise of thought. This is, in reality, the scientific method. Many people advocate the early teaching of science, but I do not. I advocate the collection and naming of plants, the love of animals and knowledge of their habits, the observation and explanation of the daily occurrences in the house, the air and the ground. The fire, a candle, the teapot, cooking, blacking boots, the dewdrop, clouds, rain, wind and storm, the ebb and flow of the tide, the performances of tops and bicycles, familiarly explained, excite a love of nature and of science, and train the mind to observe, to think and to remember. Cramming the young mind with ill-digested text-book science, illustrated by experiments that generally fail, excites ridicule—the common accompaniment of ignorance.

The engineer must be a scientific man. Science deals with the facts of nature, their laws and their theory. The engineer applies this knowledge to the uses of mankind. His practice means the correct design and due execution of works. The present President of the British Association, in his inaugural address delivered at Dover, drew no distinction between natural knowledge (science) and applied science (engineering). His illustrations to glorify the former were drawn from the triumphs of the latter. Sciences are *experimental*, such as chemistry, mechanics and physics, and *observational*, such as botany, zoology geology, geography, astronomy, biology, &c. They are very numerous, and, as engineering is only another term for applied science, it is clear that an engineer would waste his time in acquiring abstruse sciences that would be of no subsequent use to him. He must confine himself to those branches of science which will be of service to him in his future career, so as to enable him to apply them to living, industry and commerce. *Mathematics*, the shorthand of thought and the purest form of logic, *experiment*, the handmaid of observation, *measurement*, the instigator of accuracy and precision, and *reasoning*, the organ of common sense, are the tools that shape his store of knowledge which memory brings to his help when he has to practise what he has learnt. The boy who has passed well through the ordinary curriculum of school, and proceeds thence into a university, from which he emerges as a young man not only well imbued with the refining influences of literature and art, but with a well-earned degree of science, is fully prepared to commence his engineering training, and to enter the workshop or the drawing-office, where alone he can acquire that combination of knowledge and skill, and that training of the brain and the hand for mutual aid which is called technical education.

The Institution of Civil Engineers will now admit into their body only those who can produce the certificate of such an educational career as I have indicated above, or who can pass an examination which will give evidence of his possessing similar qualifications. A scientific man can become an engineer only when he has become an expert through practice and experience.

It is not a question between science and practice; it is a question between science and rule of thumb. Practice is always there, but rule of thumb means rule of error, until by repeated failures rule of thumb becomes rule of right, which means the victory of organised common sense. Organised common sense is a very good term for science. Scientific men talk nonsense when they observe differences between science and practice, and so-called practical men act foolishly when they ignore science, and assert that an ounce of practice is worth a ton of theory. Practice based on true science means immediate success and economy; practice based on rule of thumb means error, delay and excess of estimates. The engineer cannot neglect the laws of nature, any more than the scientific man can ignore the success of practice. The science of the Chair has, however, often been obsolete or behind the day. The professor is not sufficiently in touch with the industrial and economical interests of the country. It happens that in my own special branch of the profession practice has always been in advance of theory. The progress of telegraphy and telephony owes nothing to the abstract scientific man. The fundamental principles and natural facts that underlie the practice of electrical engineering are the teachings of actual experience, and not the results of laboratory research or professorial teaching. The science is, however, now established, and those who are academic students have the advantage of acquiring a knowledge of facts and principles in the class-room before they commence their practical career. Their path is thus much cleared and their progress expedited. They start well equipped mentally to grasp and comprehend the art of their profession.

Smeaton, Watt, Telford, Stephenson, Fairbairn, Whitworth, and all our early engineers had to acquire their own natural knowledge by their own individual investigations. They had to seek out and determine first principles for themselves. All that is now changed. The science of to-day is the science of the Victorian era. The engineer is not now required to research as much as his predecessors. There are now physical laboratories where it can be done for him, but this must not tempt him to lessen his enthusiasm in verifying the facts of nature by experiment. Doubt must always be transformed to faith.

The civil engineer of eminence has not only to know thoroughly the science, but to conduct the practical operations of his profession. The lives of human beings are entrusted to his designs. People have faith in the safety of his ships, long tunnels, bridges and railway trains. He is called upon to advise on policy, to deal with commercial management, to act as arbitrator or judge in many important intricate judicial cases, and to appear in courts of law and committee rooms of Parliament as an expert witness. The mental qualities of the engineer must, therefore, be of the very highest order. His scientific training and his world-wide practice have broadened his views and enlarged his mind. Above all, his character must be above all reproach. The honour of the engineer is the honour of his profession. The Lord Chief Justice's Bill was welcomed by every member of the Institution of Civil Engineers. The evil it is desired to suppress is very great and very wide, but it is not the characteristic of the engineer.

Let me, in conclusion, impress on you the antiquity and the universality of the functions of the engineer. Tubal-Cain was an instructor of every artificer in brass and iron, and this before the flood. The very earliest remains of Egyptian, Babylonian and Assyrian temples and monuments indicate a wonderful knowledge of the strength of materials. The Cloaca Maxima of the early Latin King Tarquinius Priscus exists still, though built 2,600 years ago. In the track of war and diplomacy, in the earliest days of history, went trade and commerce. The general became the engineer. Western Asia was covered with roads, not only to facilitate the transport of troops and chariots, but to assist the merchant in the distribution of his wares. Intercourse of all kinds has always been the outcome of civilisation. The balance of power falls to the strong. In days of old it was to the strong physically. In modern days it is more to the strong mentally and financially. The greatest political gift that mind can give to man, the greatest security for peace and comfort, is the ability to wield the great powers of nature so as to destroy human life with the greatest rapidity and at the greatest distance. An overpowering fleet and an efficient army are our insurance for security at home. There is not a habitable spot on the face of the earth that does not bear traces of the presence of the engineer. He is the great civiliser. He not only immediately follows, but he sometimes even precedes the military conqueror. He distributes peace and good-will without the accompaniments of fire, blood and famine. Mr. Cecil Rhodes is opening up Africa with the "wonder-working wire." Khartoum has been brought within seventy hours of Cairo by train, and ere long, when peace is restored in that self-disturbed country, South Africa, Cairo and Cape Town will be in direct and immediate communication by telegraph, and eventually by rail.

The engineer is not only a benefactor to his race, but he is a necessity of the age.

WIRELESS TELEGRAPHY.[1]

WHEN Ampère threw out the suggestion that the theory of a universal ether, possessed of merely mechanical properties, might supply the means for explaining electrical facts, which view was upheld by Joseph Henry and Faraday, the veil of mystery which had enveloped electricity began to lift. When Maxwell published, in 1864, his splendid dynamical theory of the electro-magnetic field, and worked out mathematically the theory of ether waves, and Hertz had proved experimentally the correctness of Maxwell's hypothesis, we obtained, if I may use the words of Prof. Fleming, "the greatest insight into the hidden mechanisms of nature which has yet been made by the intellect of man."

A century of progress such as this has made wireless telegraphy possible. Its basic principles are established in the very nature of electricity itself. Its evolution has placed another great force of nature at our disposal.

We cannot pay too high a tribute to the genius of Heinrich Hertz, who worked patiently and persistently in a new field of experimental physics, and made what has been called the greatest discovery in electrical science in the latter half of the nineteenth century. He not only brought about a great triumph in the field of theoretical physics, but, by proving Maxwell's mathematical hypothesis, he accomplished a great triumph in the progress of our knowledge of physical agents and physical laws.

I cannot forbear saying one word as to the eminent electrician who was placed in his last home as recently as Saturday last, for it is manifest that several years ago Prof. Hughes was on the verge of a great discovery, and, if he had persevered in his experiments, it seems probable that his name would have been closely connected with wireless telegraphy as it is with so many branches of electrical work in which he gained so much renown and such great distinction.

The experimental proof by Hertz thirteen years ago, of the identity of light and electricity, and the knowledge of how to produce, and how to detect these ether waves, the existence of which had been so far unknown, made possible true wireless telegraphy. I think I may be justified in saying that for several years the full importance of the discovery of Hertz was realised but by very few, and for this reason the early development of its practical application was slow.

The practical application of wireless telegraphy at the *present* time is many times as great as the predictions of five years ago led us to expect in so short a time. The development of the art during the past three or four years, and its present state of progress, may perhaps justify the interest which is now taken in the subject. Yet only a beginning has been made, and the possibilities of the future can as yet be only incompletely appreciated. All of you know that the idea of communicating intelligence without visible means of connection is almost as old as mankind. Wireless telegraphy by means of Hertzian waves is, however, very young. I hope that if I pass over the story of the growth of this new art, as I have watched it, or do not attempt to prove questions of priority, no one will take it for granted that nothing is to be said on these subjects, or that all that *has* been said is entirely correct.

The time allowed for this discourse is too short to permit me to recount all the steps that have led up to the practical applications of to-day. I believe it will probably interest you more to hear of the problems which have lately been solved, and the very interesting developments which have taken place during the last few months.

I find that a great element of the success of wireless telegraphy is dependent upon the use of a coherer such as I have adopted. It has been my experience, and that of other workers, that a coherer as previously constructed—that is, a tube several inches long partially filled with filings enclosed by corks—was far too untrustworthy to fulfil its purpose. I found, however, that if specially prepared filings were confined in a very small gap (about 1 mm.) between flat plugs of silver, the coherer, if properly constructed, became absolutely trustworthy. In its normal condition the resistance of a good coherer is infinite, but when influenced by electric waves the coherer instantly becomes a conductor, its resistance falling to 100 or 500 ohms. This conductivity is maintained until the tube is shaken or tapped.

I noticed that by employing similar vertical and insulated rods at both stations it was impossible to detect the effects of electric waves of high frequency, and in that way convey the intelligible alphabetical signals, over distances far greater than had been believed to be possible a few years ago.

I had formerly ascertained (see paper read before the Institution of Electrical Engineers by G. Marconi, March 1899) that the distance over which it is possible to signal with a given amount of energy varies approximately with the square of the height of the vertical wire, and with the square root of the capacity of a plate, drum, or other form of capacity area which may be placed at the top of the wires.

The law governing the relation of height and distance has already been proved correct up to a distance of 85 miles. Many months ago it was found possible to communicate from the North Haven, Poole, to Alum Bay, Isle of Wight, with a height of 75 feet, the distance being 18 miles. Later on two installations with vertical wires of double that length, *i.e.* 150 feet, were erected at a distance of 85 miles apart, and signals were easily obtained between them. According to a rigorous application of the law, 72 miles ought to have been obtained instead of 85; but, as I have previously stated, the law has been proved only to be approximately correct, the tendency being always on what I might call the right side; thus we obtain a greater distance than the application of the law would lead us to believe. There is a remarkable circumstance to be noted in the case of the 85 miles signalling. At the Alum Bay station the mast is on the cliff, and there is no curvature of the earth intervening between the two stations; that is to say, a straight line between the base of the Haven and Alum Bay stations would clear the surface of the sea. But in the case of the 85 miles the two stations were located on the sea-level, and between them exists a hill of water, owing to the earth's curvature, amounting to over 1000 feet. If these waves travelled only in straight lines, or the effect was noticeable only across open space, in a direct line, the signals would not have been received, except with a vertical wire 1000 feet high at both stations.

While carrying out some experiments nearly three years ago

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[1] Abridged from a discourse delivered at the Royal Institution, on February 2, by Mr. G. Marconi.